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ABSTRACT

The report provides additional amplification for the concepts, purposes, techniques, and procedures of economic analysis. It also focuses on and discusses potential difficulties one is likely to encounter in doing an economic analysis. The key elements of the process are discussed in detail: (1) establishing and defining objectives, (2) formulating assumptions, (3) determining and evaluating alternatives, (4) determining costs and benefits, (5) comparing costs and benefits of all alternatives, and (6) determining the sensitivity of major uncertainties. Opportunities for improvements in productivity are described as: improvement in management efficiency, adoption of advanced educational technology, reduction in cost resources, and reorganization to capture scale economics. The report contains a 14-item reference list and a three-page glossary. Appended is a 12-page section entitled "Cost Model: Discussion, Assumptions, and Limitations." (Author/MS)

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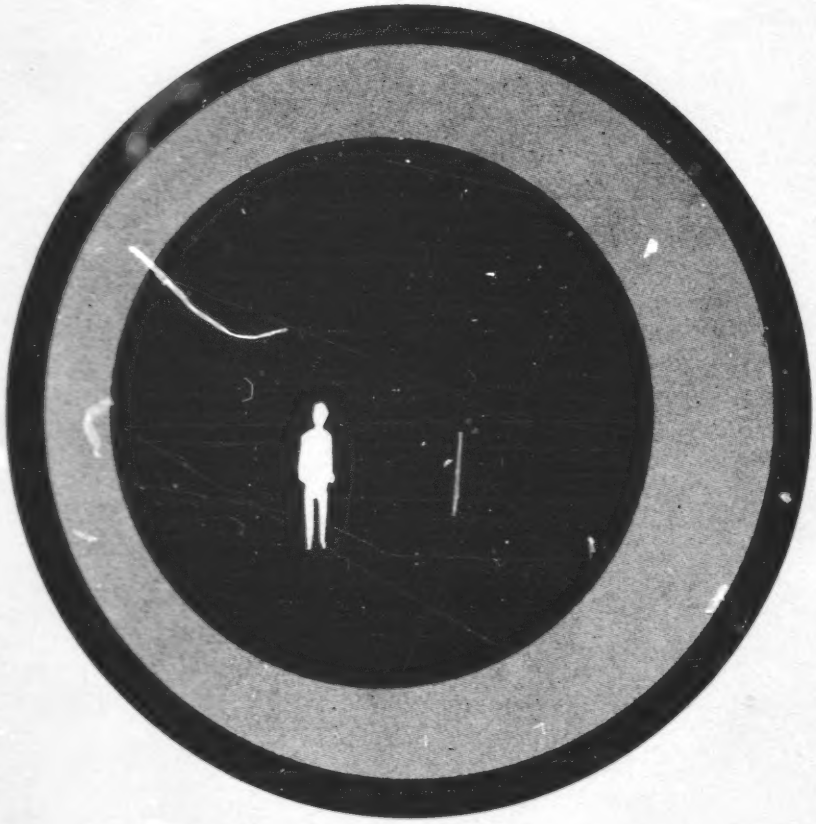
TAEG REPORT NO. 31

A PRIMER ON ECONOMIC ANALYSIS FOR NAVAL TRAINING SYSTEMS



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The purpose of this report is to provide additional amplification for the concepts, purpose, techniques, and procedures of economic analysis. It also focuses on and discusses potential difficulties one is likely to encounter in doing an economic analysis. The steps involved in an economic analysis are discussed in detail.

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William M. Swope, Ph.D.

Training Analysis and Evaluation Group

March 1976

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PREFACE

This monograph is for managers of training systems working within the Naval Education and Training Command (NET). It emphasizes the concepts and procedures of economic analysis which are relevant but not unique to Naval education and training. It is not intended to replace current publications on economic analysis, and the reader interested in gaining an understanding of economic analysis as applied within DoD should consult the official directives and publications on economic analysis. For a pragmatic discussion of the techniques of analysis, Analysis for Managers of People and Things and the DoD Economic Analysis Handbook (Ref. 1 and 4) are highly recommended. The requirements for economic analysis are specified in DoD Instruction 7041.3 and SECNAVINST 7000.14A. A list of relevant publications and directives is provided in the bibliography.

The emphasis in this monograph on Naval training must not be construed to mean that the problems encountered within the Naval training community are so unique as to require highly specialized methods and techniques for economic analysis. Given the necessary data, an analyst who has an understanding of the concepts and techniques of economic analysis should be able to perform an analysis of most training problems. The application of the standardized techniques of analysis to training problems does present special problems for measuring and evaluating the behaviorial changes manifested in the student and identifying those resources consumed in effecting those changes. However, there are many managerial decisions throughout the training command involving resource allocations which may not directly address training. For example, the acquisition of a duplicating capability within a suborganization of the command should be based on an economic analysis. When choosing among alternatives which provide the capability, the analysis need not directly address training. However, the decision on whether or not to acquire the capability at all may very well have considered the training implications.

The object of economic analysis is to get the most out of available resources. The successful manager has undoubtedly been applying the concepts of economic analysis to his decisions. However, by formalizing the analysis underlying his decisions, he will reduce the risk of faulty decisions and have available solid analytical evidence to support his decisions for budget purposes at the higher administrative levels.

Economic analysis draws on the theory of economics for the rationale and justification for concepts applied. Individuals trained in the techniques of economic analysis share a common approach. While the commonalities in techniques represent a relatively common sense approach, the explicit identification of similarities is important for an understanding of the approach. Arthur Okun, member of the Council of Economic Advisers

under the Kennedy and Johnson administrations, explicitly identified six areas where economists agree on their analytical approach--four have direct relevance to Naval education and training (Ref. 10, pp. 3-6).

These four points are outlined below. They constitute the essence of economic analysis and should be carefully considered by managers before choosing a particular alternative.

First, every economic analyst must look for opportunities sacrificed when selecting a particular alternative. A meaningful evaluation requires a careful analysis of what other objectives the alternative may impede by using up scarce resources that could be applied elsewhere. A distinction between the economist's point of view and that of the education and training specialist's is that the latter's tends to be oriented toward specific training problems. The training specialist is concerned with developing specific solutions to specific problems while the economist is concerned not only with the impact of solutions to actual problems but with their impact upon potential projects. The economist is always concerned with unrealized alternatives; i.e., "what might have been," while the training specialist is concerned with plans; i.e., "what will be."

Second, the only way output can be increased without increasing resource consumption is through improvements in efficiency and productivity. The analyst must look for improved managerial practices and technology which are more efficient and productive.

Third, the economic analyst will take a marginal or incremental approach. Rarely are decisions made which have independent effects both on resources required and outputs produced. The empirical verification and quantification of marginal effects of decisions are the most difficult part of research designed to provide information for managerial decisions.

Fourth, the economic analyst must recognize the diverse use of resources and the opportunities for substitution among them. It is difficult to find examples where resources must be combined in fixed proportions to produce a given output. In terms of Naval training, this means that any training mission can be accomplished by a combination of various resources. Which bundle of resources the manager chooses will depend upon his training goals, the technical efficiency of each alternative, and the relative price of resources. Most economic analysts would be extremely skeptical of statements or analyses which imply only a unique solution to problems. The very essence of economic analysis requires choice which, in turn, implies resource substitutability.

SECTION I

INTRODUCTION

Competing demands for limited public funds have recently resulted in a number of legislative, DoD, and Navy directives requiring full justification and analysis of both ongoing and proposed programs. The increased emphasis on economic analysis has generated a need within the Naval training community for the development of methods, data base, and expertise to perform analyses of resource allocation problems.

The requirement, justification, and rationale for analysis of resource allocation problems are not new. In reviewing past budget and managerial decisions, many managers faced with budget restrictions have responded as if these restrictions represent a new requirement for analysis. The fact is that problems of resource scarcity have been with us for a long time and will become more severe in future years. The nature of these problems differs with changes in training objectives and qualitative changes in training resources. Efficient management has required, and will continue to require, objective analyses of resource allocation problems. This conclusion is grounded in the fundamental recognition that all objectives which yield positive benefits cannot be fully satisfied from a limited resource base.

"Economic analysis is a conceptual framework for systematically investigating problems of choice" (Ref. 4, p. 2). Whether the analytical process is defined as system analysis, cost-effective analysis, economic analysis, or operations research, the ultimate objective is to aid in making those managerial decisions which lead to the most efficient use of resources. An economic analysis need be no more complicated than the problems of choice to which it is directed. It may involve nothing more than a quick mental calculation by a manager of resources. Indeed there are many day-to-day operational decisions in which the choices are so severely restricted and differences among alternatives so obvious that the marginal benefits from a formal analysis would not be great enough to justify the effort of a formal analysis. Even in these day-to-day problems the procedures of an economic analysis can be followed in an informal way. There are, on the other hand, those resource allocation problems which are so complex that a detailed analysis utilizing sophisticated analytical techniques drawn from many disciplines is necessary to gain an insight into the complex interrelationships involved. Economic analysis facilitates the decision-making process by explicitly identifying the economic implications of alternatives. A complete economic analysis should quantify those cost and output variables, where possible, and identify those which cannot be quantified.

Department of Defense Instruction 7041.3 states as policy that economic analysis will be required "for proposals which involve a choice or trade-off between two or more options even when one of the options is to maintain the status quo or to do nothing" (Ref. 5, p. 3). Economic analysis is required when resources are committed to new programs, when adjustments are being made to previously established programs, and for periodic evaluations of ongoing programs. Economic analysis and/or program evaluation studies are to be initiated as early in the acquisition process as practical and be updated as developments occur which invalidate or significantly alter the cost-benefit relationships upon which previous decisions were made.

The above cited DoD instruction provides for three exceptions to the requirement for economic analysis. An economic analysis is not required:

1. When it can be shown that the minimum level of effort required to do the analysis would not be worth the benefits to be gained from such an analysis,

2. In cases where DoD instructions and issuances prescribe equipment or age replacement criteria, labor and equipment trade-off standards, or requirements computations which in turn have been based on an analysis as called for in the DoD instruction,

3. When proposed actions are specifically directed by legislation or prior irrevocable management decisions which preclude any choice or trade off among alternatives including alternative ways to accomplish a program/project.

While the latter two exceptions are specific, the first exception places the burden on the manager to determine those resource allocations which are to be excluded from the requirements for an economic analysis.

The Navy implementing instruction for DoD Instruction 7041.3 is SECNAV Instruction 7000.14A. This instruction states that "Economic analysis will be used as an aid to management decision making at all organizational levels within the Department of the Navy" (Ref. 13, p. 1). The analyses are to be prepared at the organizational level at which a requirement for resources originates; they are to be performed with existing resources; they are to be constructed to facilitate their use for future program evaluations; they are to be summarized in the Development Concept Papers for major weapon systems; and finally, these analyses are to become an integral part of the annual budget review and used in the preparation of the Program Objective Memorandum.

PURPOSE OF REPORT

The purpose of this report is to provide additional amplification for the concepts, purpose, techniques, and procedures of economic analysis. It will also focus on and discuss potential difficulties one is likely to encounter in doing an economic analysis. The report is directed toward those resource allocation problems which directly involve training. Problems discussed will be relevant to training, although not uniquely. The report is not intended to replace existing manuals on economic analysis. Many of these manuals and handbooks present rather detailed steps which one must follow to perform an economic analysis. As a minimum, the reader should be familiar with the directives and instructions issued by the Department of Defense, the Secretary of the Navy, and the Chief of Naval Education and Training. In addition, the reader should be familiar with the Department of Defense Economic Analysis Handbook.

The report is generic in nature and aims for simplicity in presentation and content because of the wide variation in types and complexity of problems encountered. There are many resource allocation problems arising at all managerial levels throughout the training command that do not directly address training. These range from low level administrative problems, such as the type of duplication capability to acquire in support of training functions, to higher level problems, such as the most economical means of transporting recruits among training locations. For many resource allocation problems the quantification of benefits and costs is not difficult and the application of the techniques of economic analysis are relatively straightforward. Although this report is not necessarily aimed at those types of resource allocation problems, the principles and techniques discussed are highly relevant.

SECTION II

THE PROCESS

The key elements of the economic analysis process are: (1) establishing and defining objectives, (2) formulating assumptions, (3) determining alternatives, (4) determining costs and benefits, (5) comparing costs and benefits of all alternatives, and (6) determining the sensitivity of major uncertainties (Ref. 4, p. 2).

In this section of the report the steps involved in an economic analysis, as outlined above, are discussed in more detail. Since resources are scarce, it is not possible to fund all programs in which the benefits exceed costs. At some point each program or budget item must compete against alternative uses and often the marginal benefits are less than those of competing programs. Programs must then be redefined and new objectives and constraints established. The process is illustrated in figure 1.

The following example illustrates how the process might be applied to a simple problem in resource allocation. Assume that a Navy school with an annual throughput of 5000 students has a need to acquire a duplicating capability and that the average daily requirement is 500 copies for the next 10 years. The objective is to obtain a capability with at least a capacity of 500 copies per day. Assumptions may include (1) a steady level of demand each day, (2) that student throughput will not change during the next 10 years and the level of daily demand will remain constant, and (3, that each machine being considered will yield copies of equal quality. There will be a number of alternatives capable of meeting the requirements but assume that preliminary analysis demonstrated that cost differences are so great among alternatives that only two appear competitive and it is on these two that the quantitative analysis will focus. Assume also that the cost analysis between machine "A" and machine "B" shows that the annual costs are distributed as follows:

	YEAR									
	1	2	3	4	5	6	7	8	9	10
Machine A	15,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Machine B	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000

The sum of all costs for each of the 10 years for machine "A" is $69,000 and machine "B" $70,000. On the basis of the sum of these costs over the life of the project one would intuitively choose machine "A." However, because of the distribution of the costs over time we find that when these costs are discounted, machine "B" is actually the least costly alternative.

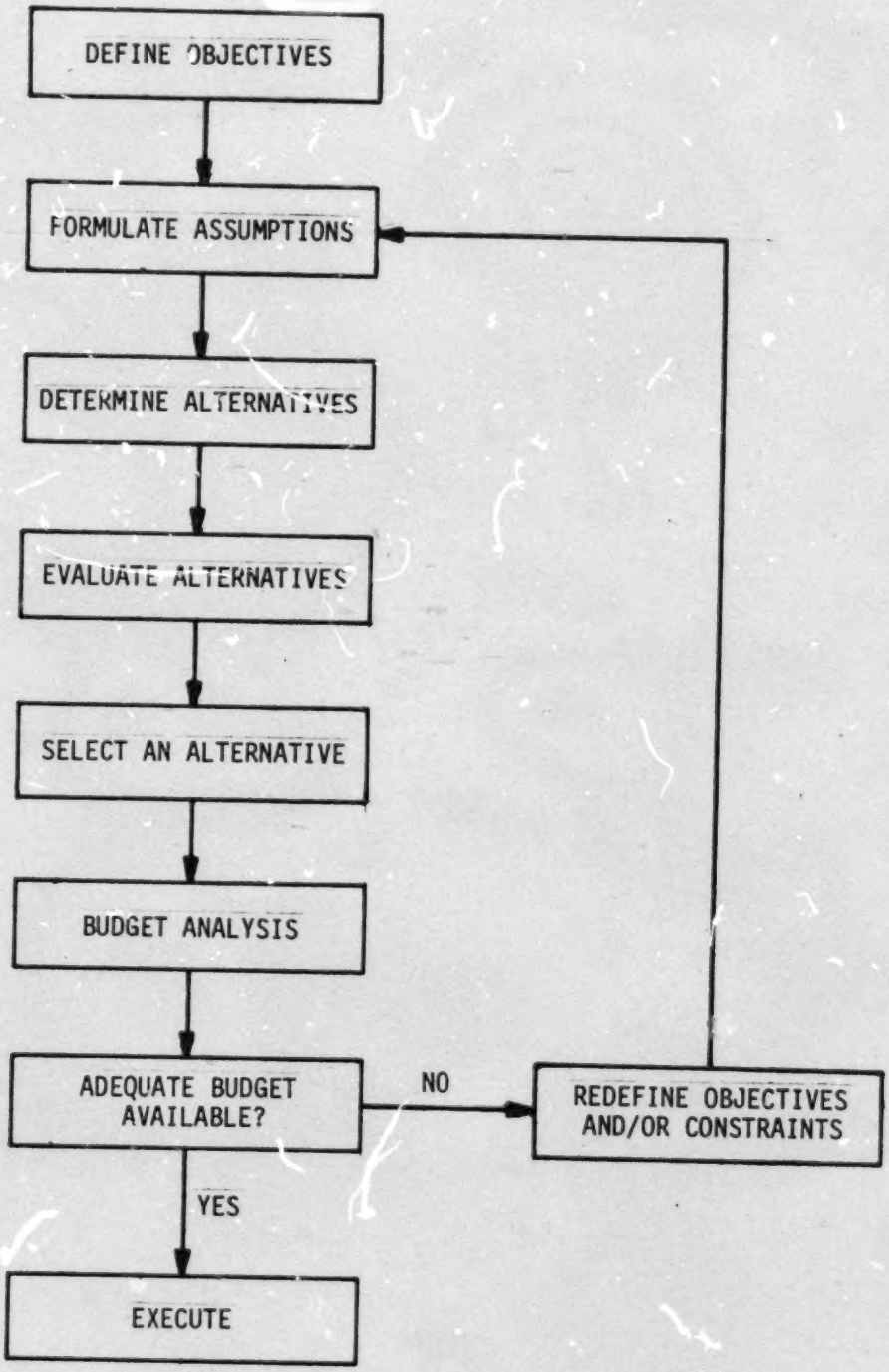

Figure 1. The Economic Analysis Process

The discounted cost over the 10 years for machine "B" is $45,129 and for machine "A" it is $47,268. Based upon this, it is more economical to choose machine "B."

Costs alone may not be the only criterion upon which a decision would be based. If the service for machine "B" is not reliable then the cost savings of $2,139 may not be sufficient justification for choosing machine "B" and the manager may still choose machine "A." In any event, there are many problems in resource allocation within the training command which cannot be made on the basis of quantifiable costs.

DEFINE OBJECTIVES

Meaningful economic analysis of training systems requires that explicit training objectives be identified. Training systems which are providing outdated, unnecessary, and invalid training cannot be economically efficient with respect to the larger goals of the Navy. A rigorous identification of training objectives provides the criteria against which feasible training alternatives can be measured for efficiency and effectiveness.

Training requirements, as measured by skill types and proficiency levels, are dependent upon the type of hardware in the operational units. Students must be trained for tasks which are relevant to their operation and maintenance. Performance standards, numbers trained and other training requirements are functionally related to the mission requirements and, to a large extent, driven by these requirements. Often a detailed task analysis is the only means of identifying the necessary training tasks with sufficient specificity to establish a training system. Given a valid set of training objectives, a fundamental purpose of economic analysis is to determine how those objectives can be met with a minimum expenditure of resources.

FORMULATE ASSUMPTIONS

The number of variables which could affect the conclusions drawn from an economic analysis are usually so numerous that it is practically impossible to deal specifically with each. Assumptions are necessary to limit the number of variables and keep the study within reasonable scope. The effects of variables which are expected to remain constant for all study alternatives are often eliminated from the analysis by stating assumptions. The user of the analysis must recognize that the validity of the study depends, in part, on the degree to which the assumptions remain valid. It is, therefore, important and necessary that such assumptions be made explicit in the presentation of the analysis.

Normally, assumptions should not be used when information can be established by factual data, especially when the factual information can be obtained with relatively minor effort. When factual information is difficult to obtain and when such information has little influence on the results then assumptions may be necessary.

DETERMINE ALTERNATIVES

A criticism often directed at economic analysis is that it is an exercise in futility since most problems have unique solutions. This criticism is valid to the extent that the underlying premise of unique solutions to most problems is valid. However, resources are so highly substitutable that one seldom finds that the resolution to any problem requires a unique set of resources. Almost any problem can be solved by numerous sets of resources. The most significant exception occurs when administrative directives or policy specify unique courses of action. Even then, substitutions are often possible. For example, administrative directives require certain aircraft engines to be removed and overhauled at fixed intervals of operation. Obviously, this places a limit on the opportunity of the manager to determine, for his particular operation, whether this is the optimal overhaul time. Although the problem of time between engine overhauls is fixed, the manager will undoubtedly have considerable latitude on how he organizes his resources to accomplish an overhaul. He should be concerned with an economic analysis of alternative overhaul procedures. It is conceivable that engine overhaul costs may differ among operational units even though all are faced with the same administrative constraints.

The rationale and underlying motivation for arguing that a given problem has a unique solution can usually be traced to one or more of the following: (1) a preferential bias toward a particular alternative, (2) a lack of knowledge about the range of technically feasible alternatives, (3) a misunderstanding about the meaning of alternatives, and (4) a propensity to focus on one solution and advocate it as the only alternative because experience and knowledge have enabled managers to define within relatively narrow limits the range of alternatives. An emotional bias toward a particular alternative which cannot be substantiated on technical and economic grounds is obviously not sufficient reason for alternative selection. The utilization of such criteria for management will inevitably lead to inefficiencies of operation. A lack of knowledge about the range of technically feasible alternatives may be due to inadequate communication on available technology, to poor training, or to an inability to understand and recognize the many alternatives available. This lack of knowledge is especially true for new technology.

A major difficulty in the utilization of economic analysis may arise from a tendency to believe that a valid analysis requires alternatives which are characterized by a great deal of diversity. Obviously, differences must exist, but these differences need not be great. Much of

the theory of economics at the operational level is based upon marginal analysis. This technique of analysis assumes that any change, no matter how small, which contributes to the maximization of objectives within the given constraints is desirable.

Economic analysis, like any other activity, consumes resources, and a trade off must be made between the degree of refinement which can be justified and the benefits which are expected from the refinements. It may be necessary and desirable to use some rather crude analytical techniques to eliminate the grossly inefficient alternatives. As differences in alternatives become less obvious and more complex, then refinements in analytical techniques are necessary.

What has come to be termed the "requirements approach" to alternative selection represents a general approach to resource allocation problems throughout government (Ref. 9, pp. 46-48 and 161-164). Operational requirements are identified in terms of what some official has deemed necessary. At this point there has been no explicit examination of the real costs involved in meeting the requirements. The requirements are then presented to a decision maker somewhere in the administrative hierarchy who has authority to approve or disapprove. Often the decision at this level depends upon whether there is an adequate budget available. The economic analysis may never enter the decision making process until an effort is made to determine the least cost method of meeting the a priori determined requirements. The procedure totally ignores the fact that an equally relevant question is whether or not the stated requirement is optimal in terms of the more global alternatives. Officials who are closely allied with operational problems tend to effectively eliminate grossly inefficient alternatives but this is not justification to focus solely on one alternative with the exclusion of all others. It is the higher level decision maker who must be concerned with the more global alternatives, and a take-it-or-leave-it proposition cannot provide a sufficient amount of relevant information to make rational trade offs. We are approaching that level of sophistication in systems design and development where a single person cannot possibly store all of the information required to optimally specify requirements and select the best alternative to satisfy the requirement.

A significant weakness of the "requirements approach" is that what may initially appear as rather innocuous trial balloons tend to become imbued with unsubstantiated objectivity by virtue of their existence. As these proposals move through the decision making hierarchy, it becomes more and more difficult to objectively analyze them and analytical efforts often degenerate into providing a justification for their existence. Analysis is necessary and relevant at all levels and is most effective when applied where problems arise. Every decision maker at every level should be cognizant of the cost of his decisions as measured in terms of alternatives foregone.

A "costing" of one alternative is not economic analysis. If a meaningful economic analysis is to be performed, then alternatives must be specified. Nearly all learning situations can be successfully accomplished with a number of alternative instructional delivery systems. One of the greater challenges of economic analysis is the identification of those alternative instructional delivery systems which are capable of meeting the training objectives. The identification of these alternative systems is best done by experts in education and training but is a necessary first step in any economic analysis. Whatever the source or means of identifying alternatives, it is necessary that they be of sufficient scope to offer a high probability of capturing a wide range of effects and thereby increasing the chance of including the most cost-effective alternative. If the most efficient alternative is not in the set to be analyzed, then it will obviously not be selected.

EVALUATION OF ALTERNATIVES

Assuming that training objectives have been specified and hypothetical alternative means of satisfying these objectives have been postulated, it is necessary to subject each to an analysis to determine the most efficient means of meeting the objectives. Each alternative must be evaluated for both its costs and benefits. The "Evaluation of Alternatives" step as previously identified in figure 1 has been broken down into further detail and each step discussed. Figure 2 illustrates the sub-process of the evaluation of alternatives.

The major steps in the Evaluation of Alternatives consist of determining the costs of each alternative; determining the benefits for each alternative; and, finally, comparing the various alternatives on the basis of both costs and benefits.

Table 1 is an outline of the issues involved in determining the costs of each alternative. Each of the topics listed in table 1 is discussed as follows (pages 14 to 28).

DETERMINE COSTS.

1. Identify Physical Resource Requirements. The first step in determining costs (see table 1) is to identify the resource requirements. Each alternative training system will consume scarce resources and the value of these resources in uses other than training is the real cost of training. The identification of physical resource requirements is necessary (or implied) before a determination of training costs can be made. The most common method of establishing resource requirements for each alternative is to develop technical resource factors which relate some unit measure of output to resource requirements. (In more technical

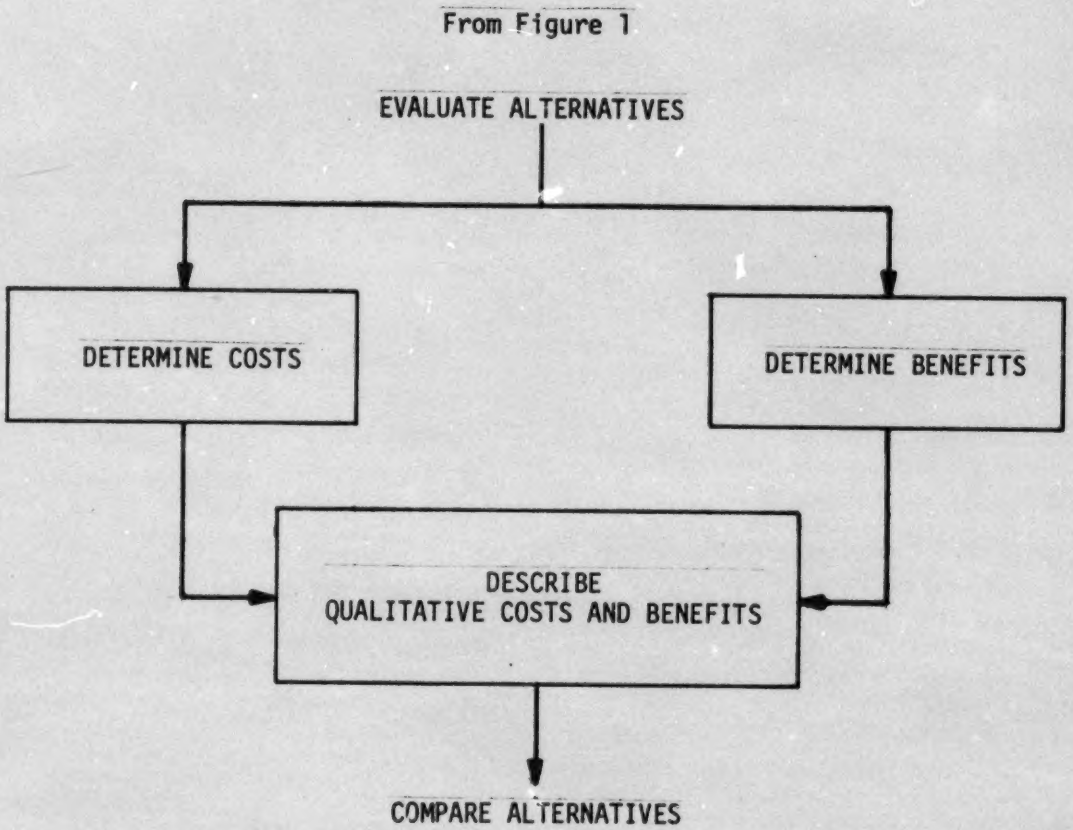

Figure 2. An Illustration of the Procedure for Evaluating Alternatives

TABLE 1. STEPS AND ISSUES INVOLVED IN DETERMINING COST OF ALTERNATIVES

A. Identify Physical Resource Requirements

Resource Classes

- Research and Development
- Implementation
- Operation and Maintenance

Resource Subclasses

- Instructional Material Development
- Facilities
- Equipment
- Expendable Supplies
- Personnel
- Student Salaries

B. Costing Concepts, Methods and Procedures

- Methods for Determining Explicit Costs
  - Cost Factors
  - Cost Estimating Relationships
  - Industrial Engineering Method
- Methods for Determining Implicit Resource Costs

C. Miscellaneous Cost Considerations

- Cost Models
- Sunk Costs
- Present Value

language these functional relationships are called "production functions."[1] Examples of technical factors are: classroom space per student, supplies per student, carrels per student, instructor to student ratios, attrition rates, equipment to student ratios, and administrative personnel to student ratios. These technical factors enable the compilation of the physical resource requirements for each alternative. Differences in these technical factors determine the differences in costs among alternative training systems.

The three major resource categories shown in table 1, within which resources may be classified are (1) research and development, (2) implementation, and (3) operation and maintenance (Ref. 6, Vol. 2, pp. 32-33). Research and development includes those resources necessary for the design and development of training devices, educational technology, instructional strategies, and any other resources necessary for the development of a feasible system. Resources required for implementation are generally acquired in one-time quantities and are normally consumed slowly over the life of the system. Such resources include buildings, facilities, and equipment. They also include resources necessary for rehabilitation, modification, or addition to land, buildings, machinery, equipment, and other capital items. The resources required for operation and maintenance of each alternative are those for which a recurring need arises over periodic intervals throughout the planning period. These resources are generally acquired each year and include both civilian and military personnel services, materials, supplies, utilities, and equipment repair.

The major resource categories (see table 1) can be conveniently subclassified into: instructional material development, facilities, equipment, expendable supplies, personnel, and students (Ref. 3, pp. 75-87).

Resources required for instructional material development represent one of the major training resource requirements. For courses which are highly specialized and complex the resources required for development of instructional material represent one of the more expensive development and implementation costs. Instructional material development is not only time consuming but requires experienced and highly skilled personnel and support equipment. Development for some highly specialized segment of courseware can require as much as 500 or more hours of personnel services per hour of instructional material development. Instructional material development costs are not uniformly high for all courses. For example, the techniques and procedures for teaching basic typing are readily available and resources required for the development of new material are minimal.

[1] The production functions show the maximum output that can be produced from any specified input set for a given technology.

Facilities include buildings, runways, and other assets normally associated with real property. Facility requirements depend upon the type of course and instructional material being used. Equipment represents those capital assets not normally associated with real property. Furniture, airplanes, simulators, student carrels, audio-visual equipment, and automotive testing equipment represent but a few of the diverse items which are properly classified as equipment. Expendable supplies are those resources which are totally consumed during the training period. Personnel services include the staff required for instruction, instructional support, and administration.

The classification of students as a training resource may seem unusual but, unlike public education, the military is required to pay students while in training. Alternative training systems which reduce training time will yield direct savings in training costs. A reduction in training time will not reduce the personnel requirements for operational units, but it will reduce the number of student training billets. Student billet reductions can be translated into a reduction in total end strength without sacrificing total Navy effectiveness. Furthermore, trainees would enter operational units earlier in their career and would in total represent a more experienced force.

2. Costing Concepts, Methods and Procedures. The second step in determining costs (see table 1) is to select a method or procedure for costing. Each alternative will require the consumption of scarce resources and scarcity implies that such resources have alternative uses. For each proposed alternative training system the resources must be identified and methods and procedures developed to evaluate their relative worth. The evaluation embodies cost analysis which "is a systematic determination of the real resource requirements (personnel, equipment, and facilities) of all candidate alternatives and the translation of such requirements into estimated dollar costs" (Ref. 6, Vol. 2, p. 26). The evaluation procedure requires that "costs" of these resources be determined, that these costs be time-phased and discounted, and that a present cost for each alternative be computed.

The costing of resources is based upon the concept of "opportunity costs." Opportunity cost is simply the value or worth of resources in their most valuable alternative use. Since almost any resource used in Navy training can be diverted to an alternative and productive use, there will usually be a positive opportunity cost associated with the use of the resource for training.

The total cost of training is the total opportunity cost of both the explicit and implicit resource costs. The explicit costs are those which involve explicit monetary or budget outlays for resources which are not currently owned or are in inventory but which are necessary to carry on the training function. These costs are closely allied with

budget dollars and include allocations for such items as personnel, student salaries, expendable supplies, travel, facility construction, equipment acquisition, and the operation and maintenance of facilities and equipment. The unit pricing of these factors presents one problem for analysis. Since these resources are purchased in the market economy or receive remuneration which is competitive to market levels, their current prices are usually a fair representation of their true opportunity costs.[2] Presumably if those resources were worth more in alternative use, their prices would reflect this increased worth and they would not have been offered at existing prices. For example, a simulation device requires the use of resources in its development and construction. The price of the device will depend in part on the payments which were necessary to retain resources in the developing and construction of the device. The price of the device then represents a substitute measure of the opportunity costs of resources that were employed in its construction. If the rewards to these resources were inadequate to attract and hold those resources, then the price of the device would be higher, thus reflecting the greater opportunity costs of those resources.

A major explicit cost of training is the personnel costs. The wages and salaries paid to students do not include the total Navy costs. The total billet costs to the Navy will exceed those payments made as wages and salaries because of retirement and other fringe benefits. Except where explicitly considered, adjustments in the personnel billet costs must be made. The Navy billet cost model published by the Personnel Systems Research Branch, Personnel Research Division of the Bureau of Naval Personnel provides an aggregate estimate of billet costs by most skill areas within the Navy (Ref. 11). The estimates derived from this model include costs for retirement, hospitals, special pay and other overhead charges. These estimates do not represent true budget costs but do represent the long-run costs which the Navy will ultimately incur to maintain personnel in these billets. For purposes of economic analysis, and in situations where overhead costs are not separated and made explicit, the estimates from the Navy billet cost model may be more representative of true costs than are the direct payments made for wages and salaries.

The implicit costs of training are the opportunity costs of using those resources which are already owned or in inventory and for which explicit monetary payments are not required. Every Navy training system will use resources which are already owned and are a part of the existing

[2] Equality between market prices and opportunity costs exists only under conditions of pure competition. However, for most problems, explicit resource requirements can be evaluated at current costs. Except in extreme cases, it is usually not necessary to make adjustments for market imperfections.

capital base. These resources have already been committed to the training community and are available without further budget outlays. Nevertheless, such resources will usually have some alternative use and their use for training will deny their use for other purposes. The real cost of Navy training includes the opportunity cost of these resources as measured in terms of their value in alternative use. The DoD directive on economic analysis states that those costs are to be included "when the existing asset is currently in use (or has an alternative, planned use) on some other project or is intended for sale. When such alternative use of the existing asset will result in a cash outlay for some other project which would otherwise not be incurred or will deprive the Government of the cash planned to be realized by sale, the value will be included in the analysis" (Ref. 5, p. 3).

The most meaningful way to compare the resource requirements for each alternative is to state all the resource requirements for each alternative in dollar equivalents. The dollar values then represent a uniform standard which can be used to evaluate each alternative. It is often a difficult task to restate the physical resource requirements into dollar equivalents for alternative evaluation. The next few pages (pages 20 to 23) will discuss procedures and difficulties encountered in this conversion.

a. Methods for Determining Explicit Costs (see table 1). The total cost of training is a direct function of the resources consumed. These resources may be physical material or the services of personnel and capital. Any costing scheme must identify and measure those resources or develop ad hoc methods which provide proxy measures of resources consumed.

If the physical resource requirements for each alternative have been identified, presumably one would have sufficient information to choose the most efficient alternative. Since physical resources are heterogeneous and difficult to compare, they are usually reduced to their dollar worth to provide a common denominator for comparison purposes. The "cost" or dollar value to be placed on the resources is their opportunity cost. The three major methods of estimating the explicit cost of training are through the use of (a) cost factors, (b) cost estimating relationships, and (c) the industrial engineering method.

Cost factors are probably the most common method of deriving estimates of the explicit cost of training. A "cost factor is a single multiplier such as a cost per unit of a resource, or a ratio relating the cost of a portion of a system to the cost of another controlling portion of the system" (Ref. 2). Cost estimates developed from the use of cost factors use both resource prices and typical values or averages of resource requirements usually derived from existing systems. The technical factors relate the resource requirements to output levels. Cost factors are the resource opportunity costs. Thus, given certain requirements

for training one is able to determine the total cost of resources by first identifying the resource requirements and then costing these resources.

Cost factors may also be ratios relating a cost of one element of the system to another element of the system. The use of such cost factors is an attempt to make direct cost estimates without explicitly estimating the physical resource requirements. While such estimates are crude they do provide a quick and ready means of focusing on relevant ranges for planning purposes. Such procedures, however, possess a number of weaknesses of which the decision maker must be aware. First, the estimates are based upon data from existing systems which may not be valid for estimating resource requirements for a new system. For example, factors on instructor costs of a conventional system would not be valid for estimating the instructor costs for a computerized instruction system. The number of instructors and skill requirements are substantially different and these differences cannot be captured in gross cost factors. A second difficulty with cost factors is that they must be adjusted to allow for scale economies which could occur by expanding the size of a system. Factors relevant for one size of a training system may be substantially different for other types of operations. For example, the administrative costs as a percentage of total system costs may differ significantly for systems of different scales. These costs are not linearly related to scale. Several cost factors would be required to accurately reflect the administrative costs if various scales are involved. The number of factors required depends upon the degree of nonlinearity and the accuracy required.

Cost estimates of proposed training equipment must carefully consider alternative equipment configurations. These decisions must be made before bids are solicited since it appears that the internal budgets of both the Government and contractors are largely determined by the amount of funds available. Many proposals require that funds be requested before the bids; thus, the amount of funds allocated provides contractors with an idea of what to bid to be competitive.

Dr. Ronald Fox, in a speech before the Department of Defense Cost Analysis Symposium illustrates how this occurs:

> A senior consultant to defense contractors in the course of the research I conducted gave me an example of how this happens. He told me of a discussion with an aerospace executive regarding a forthcoming space satellite program. The executive who expected to bid on the development contract indicated that he could probably develop the satellite for any amount from $5 million to $25 million, which is a span of 500 percent from the low to the high estimate, and that he believed such a satellite would achieve the minimum mission

objectives specified by the customer. As soon as the company executive knew how much money the Government had allocated to this development program he would know, in good faith, what kind of a satellite to build. In his proposal to the Government, he intended to emphasize the importance of cost control and his ability to deliver an effective program for the approved cost. Once the customer decided how much money he had available for the development of the satellite, say $15 million, this contractor like most others, would design a satellite costing at least $15 million. Neither the contractor nor the customer would ever know how much additional value, in terms of performance or new missions, might have been achieved for a $17 million satellite. Similarly, it is unlikely that they would know how much their mission requirements would be affected if they developed a $13 million satellite (Ref. 8, pp. 22-23).

If meaningful economic analysis is to be done for equipment expected to be procured through contract, this analysis must precede the budget submission in which that equipment will be requested as a line-item. After funds have been identified it appears that expenditures will rise to consume the available funds.

Cost estimating relationships (CER's) are functional relationships between physical and performance attributes of a training system and dollar costs. A CER estimates costs, often without explicitly identifying the resources associated with the training system. These relationships are established by gathering data on training systems over several periods and then developing the parametric relationships through the use of inferential statistical techniques. Such relationships may be bivariate or multivariate models, that is to say, a CER may be a model in which cost is related to one single training variable or attribute, or the CER may be a model in which cost is related to several variables or attributes of the training system. These models are derived using multiple regression techniques on either time series or on cross sectional data. Because such models require time to construct and can involve some rather sophisticated analytical techniques, they are a tool which is not usually available without some preplanning. Data must be maintained and these models developed so that they are available when needed.

Reliable CER's will usually require the use of several independent variables. Examples of variables which might be appropriate are (1) instructor to student ratios, (2) square feet required per student, (3) ratio of classroom to laboratory time, (4) instructional techniques, (5) location of training, (6) student time in course, and (7) stage in the training. Each development of a CER is unique and the selection of the appropriate variables would require an analysis of each specific situation. What may be appropriate variables for the development of one CER may be inappropriate for another CER. The most important

requirement in establishing valid CER's is to identify those attributes of the training system which are highly correlated with costs. By identifying and adding a sufficient number of highly relevant variables, relationships can usually be developed which explain a very high percentage of variation in training system costs. The fact that a high percentage of variation in system costs can be explained with a specific CER does not necessarily justify the conclusion that this same CER can be used to estimate with the same reliability the cost of a new or different system. New or different training systems seldom exhibit the same characteristics as those on which old CER's were based.

Changes in relative resource costs can reduce reliability of CER's which are based upon data not reflecting existing resource price ratios. Increased personnel and energy costs relative to other resources represent the two most recent and notable examples where changes in resource price ratios may be important. A move to the all volunteer force was associated with substantial increases in both the relative and absolute level of military personnel costs. Personnel costs represent a major element of total training costs and the relative shift in costs has important implications for the design of training systems. Cost estimating relationships based on data which do not reflect these increased personnel costs would tend to underestimate the costs of training systems which were more labor intensive relative to those which were more capital intensive. To be most useful and valid CER's must be developed for training systems which are relatively homogeneous and they must be periodically updated to reflect changing technology and changes in relative resource costs.

A costing procedure known as the Industrial Engineering Method requires that the system being analyzed be broken-down into elements or components and costs estimated for each component (Ref. 4, p. 10 and Ref. 6, Vol. 2, pp. 36-37). These costs are then aggregated into the total system costs. This method requires an intimate knowledge of the system being analyzed so that meaningful system elements can be identified and costed. The data requirements for this procedure are so rigid that this method will usually not be satisfactory for analyzing training systems. There are, however, many resource allocation problems within the training community which occur at the lower operational levels for which the method may be extremely useful. For example, to develop the explicit costs of constructing a training simulator, the Industrial Engineering Method may well be the most desirable procedure.

In general, "The approach... would appear to have limited application in economic analysis. Generally, the analysts would have neither the necessary information nor time to develop true engineering estimates. Make or buy studies ... may be one area where industrial engineering estimates would be appropriate" (Ref. 6, Vol.2, p. 37).

b. Methods for Determining Implicit Resource Cost (see table 1). The value or opportunity cost of existing assets are to be computed at their fair market value. If the resource has an alternative use then its value in such use might be measured by the amount of expenditures which could be avoided. Replacement value or the cost of replacing the existing resource with a similar new resource can be used as the basis for estimating value. To estimate the value of the existing resource, the new cost must be properly discounted for obsolescence, wear, and refurbishing. An estimate of expected selling price could provide another basis for determining resource opportunity costs. For those resources which have no alternative use because of obsolescence or wear, their value may be limited to the worth of raw materials for recycling. Rapid advances in military hardware and similar advances in educational technology have forced many resources into obsolescence.

It is almost impossible to build and maintain a data base for computing the implicit resource costs. The opportunity costs of existing assets are highly situational specific; i.e., their costs depend upon circumstances surrounding each analytical situation and must be uniquely determined for each problem.

3. Miscellaneous Cost Considerations. A number of peripheral issues involved in estimating costs of alternatives are discussed in the next few pages (pages 24 to 28). Cost models, utility models, sunk costs and the concept of present value and discounting will be discussed.

A cost model can be considered to consist of two fundamental parts. First, the model must relate the training accomplished to the resources consumed; and second, the resources consumed must be reduced to a common denominator so that alternatives can be compared for efficiency.[3] The first part of the model which specifies the relationship between training accomplished and resources consumed is defined as a "production function" in economic terms. This relationship reflects the current state of educational technology. Differences among alternatives are most often reflected in changes in these technical relationships and the cost model must be sufficiently general to allow the technical factors to be varied. These technical relationships will change because of technological development.

The second part of a cost model reduces the resources required to a common denominator so that meaningful comparisons of alternatives can be made. The only meaningful way of making such comparisons, at the present time, is to restate the resource requirements into dollar terms. Therefore,

[3] An example of a cost model designed to evaluate the economic implications of alternative instructional delivery systems is presented in appendix A.

each resource element must be "costed" and entered into the cost model as part of the input data. The relevant cost of each resource element is determined by the value of the resource in alternative use; i.e., the opportunity cost of the resource. The cost model must have the capacity to handle alternative training systems in which resources are required in different time periods. The model must be capable of time-phasing and discounting future resource requirements so that costs being compared are consistent with respect to time.

Work is currently underway to develop utility models for evaluation of alternative systems (for example see Ref. 12). These models base their selection of alternatives upon an a priori determined utility function. However, until utility models are more fully developed and greatly simplified, they will be of limited use to operational managers. Most operational decisions will continue to use the more conventional cost optimization models and benefit-cost analysis.

In determining the cost of each alternative it is inappropriate to include sunk costs. These costs are the payments made for resources prior to the decision point. While the amount of those payments are to be excluded, the resources acquired from the past payments are not to be excluded. Assume, for example, that the total cost for research, development, and acquisition of a simulator for Navy aircraft was $2 million and that this simulator is now being considered for use in an improved training system. Assume further that if the simulator is not used for Navy training that it can be sold to commercial aviation for $500,000 and that it has no other alternative use beyond the two mentioned. The $2 million is "water over the dam" and need not be considered by the Navy in its decision to use the simulator. However, the real cost to the Navy of using the simulator is $500,000 and it is the only cost with respect to the simulator which is relevant. Although the original cost of the resource is not considered in the analysis, current value in alternative use of the resource must be considered. Note also that the opportunity cost of assets used in the existing system should be deducted from the cost of other alternatives if the existing system is not a viable alternative.

A valid comparison among alternatives requires that outyear expenditures be stated in present value terms. The procedure of converting future resource requirements into present values is called discounting. The discount rate is the amount future values are discounted and is the rate of return one could expect to earn by investing the funds in interest bearing assets. Adjustments in the discount rate are often made for risk and inflation. According to DoD Instruction 7041.3 the discount rate applicable to DoD investments is 10 percent.

An alternative which can defer until future years a significant portion of the investment and/or operating expenses is less costly in today's dollars than a system which may immediately require the same absolute investment. We as individuals (and society in total) exhibit "a positive rate of time preference;" i.e., consumption today is preferred over consumption tomorrow. The price paid for indulgence in this preference is the interest rates on money. Those who are willing to defer their consumption, receive interest as rewards. It is not only theoretically prudent to discount future cost and income streams but we are directed by DoD policy to do such discounting when comparing alternatives.

Differences among alternatives exist in both the amount of resources required and in the time at which the resources will be required. Certain alternatives may have heavy initial capital investment costs and low annual operating costs over their expected life. Other alternatives may require low investments but will have high annual operating costs. A valid comparison of alternatives must consider both the total resource requirements over the life of the project as well as the time at which the resources will be required. Although two alternatives may have the same undiscounted costs (over their life), under "ceteris paribus" conditions; i.e., all other things being equal, the one with the lowest present costs is preferred.

The present cost of any alternative is the amount of money that would be required on "day one" to finance the alternative (when a specified percentage could be earned over the entire life of the project). Therefore, if the manager was able to acquire in the first year an amount of funds equal to the present cost, then he would have sufficient funds to operate the system over its entire life. The present cost of alternatives is the proper basis for selecting the most economically efficient alternative.

An algebraic expression of the present cost (PC) of an X_i amount of dollars which will be spent in the i th year follows:

$$PC = \frac{X_i}{(1+r)^i}$$

where r is the applicable interest or discount rate.

The present cost of an alternative is computed by summing the present costs for each year in the planning period as follows:

$$\text{Total present cost of Alternative} = Z + \sum_{i=1}^{N} \frac{X_i}{(1+r)^i},$$

where Z = the total undiscounted investment costs.

If one assumes uniform cash flows throughout each one-year period ($X_1=X_2=X_3 = \ldots X_n$), then the discount factors found in table 2 can be used to compute the present value for each year. The factors in table 2 use a discount rate of 10 percent as directed by DoD Instruction 7041.3 and are computed by taking the arithmetic average of beginning and end year compound amount factors found in the standard present value tables.

DETERMINE BENEFITS. A second major step (see figure 2) involved in the evaluation of alternatives requires that the benefits of each alternative be identified and quantified to the extent possible. The real benefits of Navy training are defined in terms of improved job performance. Reductions in accident rates, downtime, equipment failure, and improvement in fulfilling mission objectives are examples of the real training benefits. These benefits are the basis of establishing the requirements for training by operational units.

Training objectives must be valid as measured by relevancy to the job that is to be performed. Furthermore, these objectives must be set in cognizance of benefits to be achieved vice the costs of meeting those objectives. Assuming a valid set of training objectives, it is the responsibility of managers within the Naval Education and Training (NET) Command to devise training systems which will enable students to achieve the training objectives with minimum expenditure of resources. If every training system under consideration were capable of training students to proficiency levels which exactly matched the training objectives, then the most economical system is that one in which resource consumption was at a minimum. It is unlikely that any training system can be constructed that will exactly meet training objectives. Therefore, differential training effectiveness of alternative systems is one output measure that should be used to evaluate alternative systems. Effectiveness is defined here to mean the degree to which the objectives of training have been met.

It is difficult to derive valid criteria for determining the degree to which students have achieved the training objectives. Effectiveness of training systems is one of the basic criteria for selecting from among training systems. Procedures and techniques for determining effectiveness are not well defined and most decisions on system effectiveness have probably been, and will continue to be, dependent upon the judgment of individuals who are familiar with effectiveness measurement.

Managers at the operational levels within the NET Command are usually not able to determine the real long-range benefits of training as measured by improved job performance in the operational fleet. A typical problem faced by most managers is how to select that system which is most efficient in meeting a specified set of training objectives. These managers are not concerned with the real long-term benefits of

TABLE 2. DISCOUNT FACTORS BASED UPON A 10 PERCENT DISCOUNT RATE

Project Year	Present Value of Dollar
1	0.954
2	0.867
3	0.788
4	0.717
5	0.652
6	0.592
7	0.538
8	0.489
9	0.445
10	0.405
11	0.368
12	0.334
13	0.304
14	0.276
15	0.251
16	0.228
17	0.208
18	0.189
19	0.172
20	0.156
21	0.142
22	0.129
23	0.117
24	0.107
25	0.097

training. They are concerned with costs and benefits as measured by differences among alternative systems, rather than the long-term benefits of training.

The evaluation of each system will require measures of output and quality, some of which can be quantified but many others which simply cannot be quantified in any meaningful way. The characteristics of criteria for determining the advantages or benefits of one system over another should be discreet, discriminate, and quantifiable. Measures must be discreet to avoid commingling of benefits which leads to ambiguous measures. The criteria should be discriminative in order that meaningful differences can be identified and evaluated. Finally, quantification is desirable for it provides for unambiguous evaluation of each system with respect to the criteria under consideration.

Following is a list of criteria against which the benefits of one system may be compared with another. Each problem and system will require unique evaluation criteria so the following list is not intended to be all inclusive.

1. The degree to which the training objectives are satisfied. Under ceteris paribus conditions; i.e., all other things being equal, the training system in which the highest proportion of students achieve the training objectives is preferable.

2. Output capacity of the system. This is an important consideration for systems in which there are large fluctuations in throughput or where requirements for numbers trained are expected to increase.

3. Adaptability of the system to changing technology. Rapid changes in training requirements have occurred in many skill areas, especially in electronics. Heavy investments in instructional systems which have a high probability of being rapidly outdated are usually less desirable than systems which can adapt to the changing technology.

4. Capacity to train students of differential ability. The capability of a system to adapt to variability in student quality is a significant factor in many training systems.

5. Safety. The relative safety of alternative systems may be important. For example, it is an important consideration in a decision to substitute simulation time for actual flight time in pilot training.

There are a number of costs and benefits of training which are incommensurable; i.e., there is no meaningful way they can be measured and objectively compared. Quantifiable and unambiguous measures of many costs and benefits of training are not possible. Often these costs and benefits may well constitute the most important criteria used in evaluating

alternative training systems. The nonquantifiable costs and benefits being considered should be germane to the analysis. Statements of and amplification of these costs and benefits must be in narrative form and should emphasize their importance as related to the training mission. Managers responsible for a system must ultimately weigh both the quantitative evidence as well as qualitative evidence to arrive at a decision. The analysis should identify and make explicit this information to the decision maker.

COMPARE AND SELECT ALTERNATIVES

Assuming that all costs and benefits have been identified and quantified to the extent possible, it then remains to compare and select an alternative (see figure 1). If all costs and benefits can be quantified and made comparable then selection is straightforward. However, the benefits occurring to the Navy are not easily quantified--in fact, it is difficult to make meaningful qualitative statements on many training benefits. Also, some of the cost data will embody a certain amount of inaccuracy in judgment. Nevertheless, data must be brought together and decisions made as to the desirable alternative.

Most resource allocation problems, especially in training, can be discriminated on the basis of variation in both outputs and inputs. However, the variation is a matter of degree. For many training systems this variation may be so slight that analysis can proceed on the basis of holding either outputs or inputs constant. Whether justified or not, most analyses probably proceed on the latter basis.

When the outputs and/or benefits of all alternatives are considered equal then differences in costs are sufficient evidence from which to select the most efficient alternative. Only those alternatives which would meet the minimum training objectives would be considered and the least cost alternative would be selected. This is referred to as an "economy solution." If a reduction in the budget is the primary objective then economy solutions should be selected. The economy solution is probably the most widely applied method today in education and training because the benefits of training are so difficult to quantify.

When managers are operating with a fixed budget, the objective is to maximize training outputs as measured by both quantity and quality. If all alternatives require the same budget, then differences in outputs (training proficiency and numbers trained) provide the evidence on which to select from among alternative training systems. The attempt to obtain the maximum from the available resources is called an "efficiency solution." Dr. Ivon W. Ulrey, Economist at the Naval Postgraduate School, believes that most managers, "are deficient in describing which solution (efficiency or economy) is being sought--therefore, efficiency is usually assumed as the desired strategy. In fact, if a manager achieves an economy of operation, he may be penalized by a cut in budget, rather than rewarded" (Ref. 1, p. 2).

UNCERTAINTY AND SENSITIVITY ANALYSIS

Characteristically, economic analyses involve elements of uncertainty. Uncertainties may be associated with elements of each step in the economic analysis process but are especially important for the assumptions and the data. Uncertainties arise from political, technical, and economic conditions outside the control of the decision making unit.

When changes in variables or assumptions of the analysis lead to substantial differences in the economic feasibility of alternatives, a sensitivity analysis should be performed. A sensitivity analysis uses a range of discreet values for variables which have a relatively high probability of varying. The objective of a sensitivity analysis is to determine how sensitive the major conclusions would be to changes in the more significant parameters of the analysis. Such information enables the decision maker to more reliably estimate the potential implications of his decisions and to more accurately determine the probability of errors which might result in costly managerial decisions.

BUDGET ANALYSIS AND PRIORITIZATION

An alternative may be both economically and technically feasible but if it cannot be funded within the existing budget there is little hope of implementation. There is, therefore, a need to translate the resources required for implementation and operation into appropriate funding categories. The budget requirements for each alternative must be compared with other competing alternatives and allocations made. When used appropriately, economic analysis is one of the primary tools used by management for making budget allocations.

The problems of the budget analysts are essentially those besetting the economic analysts. Yet, conflict often arises when results of economic analysis in support of proposals are presented to budgeteers. Characteristically, the cost estimates of economic analysis are regarded as "fairy tales." Discounted costs, for example, have no budget analogues and when the budget must be defended before appropriation committees "present costs" are relatively meaningless numbers. The budget must specify the hard nondiscounted dollar requirements. The problem is exacerbated by the feature that in an economic analysis costs are often attributed to the use of resources which need not be supplied from current budgets. Many of these resources are already owned by the agency.

Supporters of the economic analysis approach criticize a purely budget oriented approach for failing to consider the real value of the resources consumed in the agency activity. The budget approach identifies what is spent each year for training but does not address the real long run costs of training. Such an approach is accused of emphasizing short-term gain at the expense of long-term savings. It fails to consider

the time-value of resources and will often lead to the funding of projects which have unnecessary high social costs. Budget decisions are often agency oriented and too often the support for proposals and programs depends upon the impact on the agency budget. Thus, proposals are often given a comparative advantage if it can be demonstrated within the proposal that a significant amount of funds and support will be provided by sources outside the funding agency.

A good deal of the controversy between budget analysis and economic analysis has its origin in the "stock" and "flow" characteristics of resources. In Navy training the flow resources represent the annual budget dollars and the stocks are primarily made up of the vast investment in facilities, equipment and instructional material which is available for Navy training. Stocks and flows are variables which may grow smaller or larger in quantity. A stock is a quantity measured at a given point in time. Stocks can be consumed by economic activity or they can grow through additions with flow variables. A flow is a rate measured only over some specified period of time. Both the numerical magnitude of stock and flow resources can change over time.

If resources could be efficiently acquired and completely consumed as training occurs then investments in capital stocks would not be necessary or possible. In planning for future activity there would be no requirement to evaluate existing capital stocks since none would exist. Nor would there be a need to evaluate any residual stocks which exist at the end of the planning period since all resources acquired would be completely consumed. Obviously, resources do not lend themselves to such patterns of use. A relatively large capital base is necessary to carry on economic activity, whether it be Navy training or industrial production. The capital base constitutes those resources which must be provided and acquired in discrete blocks but which yield their services over an extended time period. The treatment and emphasis placed on these capital stocks or existing resources represents one of the fundamental difficulties between the budget approach and economic approach.

A simplified version of the economic-budget analysis controversy is described in what follows. Economic analysis attempts to determine the worth of all resources, whether they be classified as stock or flow resources. Budget analysis emphasizes the flow resources and is concerned only with stock resources to the extent that the need to replace or add to such stocks impinges upon current flow requirements. The emphasis on flow variables probably can be ascribed to the fact that in past budget hearings, the agency has seldom been required to defend the use of its capital stocks. The emphasis of the funding agency has been on the annual budget with less regard to how the size of the budget impacts on the capital base. Those submitting budgets must respond to these requirements and have done so.

The economic worth of a given program cannot be determined by an independent evaluation of that program. The relative worth of a program in furthering the organization's mission or goals must be measured in terms of other potential uses for the limited resources. All programs which yield positive benefits cannot be funded from a limited budget. The decisions include which programs to fund and the level of funding. The marginal benefits resulting from any program will vary with particular operational levels. Because of diminishing returns there will be some level of funding beyond which the program benefits will not be adequate to justify further expenditures on that program. Because of diminishing returns, the reduction in total Navy training effectiveness will be minimized by spreading the limited budget over several training programs or systems vice the arbitrary ranking and total elimination of programs until budget constraints are met. For example, it may be more beneficial to the Navy to train several skill levels to some minimum performance level than to eliminate training for several skill areas in order to have the resources to train a few individuals in other skills to a very high proficiency level. Obviously, in allocating the budget all competing demands for resources must be examined and their relative worth determined.

The technique for allocating resources in a manner which maximizes the attainment of the training goals is marginal analysis. The essence of the technique is that each competing alternative is evaluated in terms of its total value to the Navy and on its impact of incremental changes in funding levels. By following such an approach some alternatives may be funded at lower levels than originally proposed, some may be funded at higher levels, while others may be totally eliminated. If "What's best for the Navy" is the paramount management objective, then marginal analysis is the proper means of establishing spending priorities. As an illustration, assume that alternatives have been prioritized by some arbitrary scheme and the priority 1 item requires $10 million and the priority 2 item requires $1 million. The relative rankings are only correct if the last million dollars spent on item 1 is worth more than the cost of item 2. Thus, if the budget is limited to $10 million the preferable alternative may be to fund item 1 at $9 million and item 2 at $1 million, rather than spending all $10 million on the number 1 ranked priority.

It is axiomatic that budget requests will be greater than funds available, forcing an allocation among competing programs. A ranking of objectives according to some arbitrary prioritization scheme is inadequate guidance for allocation decisions. Any meaningful ranking must be based upon the opportunity costs involved with each objective.

The importance and purpose of economic analysis in determining spending priorities is discussed by Edward R. Winchester, Management Analyst in the Office of the Assistant Secretary of Defense (Ref. 14).

Sound economic analysis is an essential part of the process of ordering spending priorities for the Defense Department. In an environment where demand exceeds the available supply of funds and fiscal guidelines impose budget constraints, investment proposals must be evaluated on their relative merits, and priorities established. In other words, the analytical techniques of economic analysis must be used by management at all levels. It is only by determining programs and projects which are capable of attaining required objectives, programs which have outlived or attained required objectives, and programs whose benefits are in excess of their costs that it is possible to begin to lay a basis for ordering priorities. This is the purpose of economic analysis.

It is difficult to establish quantifiable and unambiguous ranking criteria. For high levels of management where goals can only be stated in very general terms a good deal of judgment will be required to make efficient allocation of resources. It makes little sense to develop precise allocation techniques to meet general management goals. Such techniques would probably be misused and lead to less efficient allocations than those made on a rational judgmental basis by individuals familiar with training problems.

Administrators who are faced with budget allocation decisions should determine what criteria are important for the ranking of spending priorities. If organizational objectives are well defined then the criteria used to evaluate competing alternatives can be selected. If organizational goals and objectives are not well defined then there is little hope of establishing meaningful criteria with which to determine spending priorities.

Assuming that high level management can make explicit the criteria for establishing spending priorities, then economic analysis provides a technique by which each alternative demand for funds can be evaluated. Budget allocation decisions would be greatly simplified if all requests for resources were supported by an economic analysis which addressed the appropriate decision making criteria. Too often, alternatives are selected at lower levels on the basis of criteria which are inconsistent with higher level goals or objectives. This is a real problem which is amplified by the military chain of command structure. Constraints which force suboptimization using inconsistent high level criteria are not in the best interests of the Navy. Each situation requires unique evaluation as to appropriate criteria. "Clearly, there is no all purpose criterion, for the appropriate test depends upon what alternatives are open to the decision-maker, upon what aspects of the situation must be taken as given, and even upon what kind of measurements are feasible" (Ref.9, p. 174).

SECTION III

OPPORTUNITIES FOR IMPROVEMENTS IN PRODUCTIVITY

The simple question, "Can training costs be reduced?" must evoke an unqualified yes. It is always possible to reduce the total training budget--especially in the long run by reducing the quantity and quality of training. Budget decisions which dictate a reduction of training resources without a corresponding reduction in training requirements are valid to the extent that the current training system is inefficiently managed, more efficient technology is available and not being utilized, and/or a reduction in resource prices is imminent. It is the purpose of this section to identify the characteristics of an efficient system and to focus on areas where adjustments in management and policy may lead to improved efficiency.

A technically efficient system is one which makes it impossible to increase one valuable output without increasing a valuable input or decreasing another valuable output. Economic efficiency imposes the additional constraint that the training tasks and objectives be evaluated with respect to program objectives and resource costs.

Any managerial adjustment which improves technical efficiency will be a move toward economic efficiency. Technical efficiency is a necessary but not sufficient condition for economic efficiency. There may be several technically feasible training solutions of which only one is economically efficient.

Economic efficiency must include a conscious recognition that any training system being recommended is optimal only to the extent that resources consumed for training cannot be redirected to other uses which will make a greater contribution toward accomplishing the Navy mission. "Other uses" include both training and nontraining alternatives. At some point and at some administrative level in the resource allocation processes, it will be necessary for every training system being recommended to be evaluated against other potential uses for the Navy's resources. The training system being recommended or developed must not only be the most efficient system for meeting the training objectives for which it is being designed, but the resources must be worth more when used for training than for any other Navy use. For this reason, it is important that requests for training funds be documented as to their full Navy benefits so that they can compete favorably with other requests for resources.

Economic efficiency requires that all training objectives be relevant and set at reasonable levels. In setting training objectives, both the mission requirements and resources necessary to fulfill the training

objectives must be considered. The flexibility in determining training objectives is largely determined by performance norms of the operational units. Some tasks may be so critical and the operational requirements so rigid that the range of performance requirements is severely restricted. For example, a pilot must reach a level of proficiency which at the minimum will insure a high probability of initial success in solo flight. The cost resulting from loss of life and property is so high relative to training costs that rigorous training standards cannot be sacrificed. There are other tasks which are less critical and requirements may be such that operational effectiveness will be unimpaired over relatively wide ranges of training. In summary, training objectives cannot be set independently of mission requirements and there are few, if any, situations where mission requirements should dictate the level of training without considering the costs involved in attaining that training.

It makes little economic sense to determine training objectives, to devise a training system to meet those objectives, and then advocate the system as providing the only possible solution to the training problem. As McKean has so vividly illustrated "One cannot properly draw up (training) plans on the basis of cost alone or needs alone. There is no budget size or cost that is correct regardless of the payoff, and there is no need that should be met regardless of cost" (Ref. 9, p. 47).

Four basic areas (not mutually exclusive) where administrators may seek improvements in efficiency and productivity are: (1) The adoption and implementation of more efficient management techniques, (2) utilization of more efficient educational technology, (3) reduction in the cost of resources, and (4) reorganization of the training program to capture scale economies. Each of these areas is discussed in the remainder of this section.

IMPROVEMENT IN MANAGEMENT EFFICIENCY

Management techniques employed impact heavily on the efficiency with which resources are used and often the only significant savings possible are through improvements in management. The following discussion will focus only on those aspects of management which are highly relevant to economic analysis.

Often managers making operational decisions at lower organizational levels for short time periods have little opportunity to control the quantity and quality of those resources which are part of the fixed resource base. However, operational managers do have considerable latitude in making managerial decisions for those resources already available. Decisions which may have little bearing on quantity and/or quality of resources used but may influence the quantity and quality of training are those dealing with personnel policies, scheduling, operation and maintenance procedures, and administration policies.

At higher administrative and organizational levels and for longer planning periods, more opportunities arise for resource substitutions and true long-term economies are possible. Administration policies established at higher echelons of command may place constraints on low level management which force inefficient operations. To maintain an effective and efficient training organization, a certain degree of operational flexibility is necessary to enable management to respond to changes in resource markets and new technology. Budget constraints which hamper this flexibility and which categorize resources into rigid classes can impede efficient management.

Administrative policies and directives which dictate changes in output with time constraints so short that resources cannot be matched to new output levels also contribute to operational inefficiencies. Resource markets, technology, and training requirements do not change in response to budget and administration edicts. When changes do occur, they do not occur at discrete and well-timed intervals which coincide with the fiscal year or any a priori determined planning period.

At any point in time, management decisions which involve the utilization of resources must deal with the fact that some will be subject to manipulation, while others, by their nature, must remain fixed. The operational decisions which managers make are essentially decisions on how to effectively combine the variable resources with the fixed resource base to meet the training objectives. The planning decisions involve how best to adjust, in the long run, the fixed resource base to attain long-term efficiency.

THE PLANNING PERIOD. Long-run planning commitments made in the present effectively place limits on the operational options that will be available in future periods. For this reason decisions to undertake certain investment options may well depend on the degree of flexibility necessary for future periods. This, in turn, is fundamentally related to the degree of uncertainty involved in the decision. The planning period is a relative time dimension and, in the absence of administrative constraints, all resources are presumably variable and can be devoted to their most efficient use.

Because of the time lag in acquiring resources and technical characteristics of training resources, an efficient training system requires considerable forward planning. Instructors must be trained, equipment must be ordered and installed, instructional software and hardware must be developed, and administrative procedures established. Many training resources must be acquired in discrete quantities and will not be totally consumed by training which takes place in the immediate future. These resources may be available for many years to come and forward planning must recognize and evaluate the future availability of those resources. Furthermore, these resources must be meshed together into an efficient system which requires an evaluation of both their technical and temporal characteristics.

Because the operation and maintenance of hardware systems impact on training, any rational decision on hardware acquisition must consider and evaluate the training resources necessary to support the system. If training requirements have been identified and evaluated, as they should have been in the acquisition of hardware, then the necessary funds should be committed to the training with sufficient lead time to permit full flexibility in the design, development, and implementation of an efficient training system. Training required for the sophisticated military hardware must employ training resources which are not highly fungible. Because of the sophisticated hardware, the lead time necessary for the development of an effective and efficient system is more important now than in the past. Insufficient lead time in identifying and funding new training requirements is often a reality and a major contributing factor to training inefficiencies.

THE OPERATIONAL PERIOD. Just as future operational options will be limited by present planning decisions, the present operational options were set by past planning decisions. Because of uncertainty, changes in technological factors, and imperfect planning, most training systems will not be optimally designed in terms of their current training requirements.

Operational decisions deal largely with variable resources and are characterized by a high degree of flexibility. They involve only short term commitments and do not lock resources into long term programs. Often such decisions are easily reversible over relatively short periods and such reversals often can be made with minimal economic loss.

There are two relevant issues which must be addressed for each operational decision. The first issue requires a determination of which resources are relevant to the decision and what value (or cost) must be placed on those resources. The relevant resources are determined by the time frame of the decision and the administrative level at which such decisions are made. The higher the administrative level, the more latitude the decision maker is likely to have in determining alternative resource use. What, therefore, may be considered a relevant cost at high administrative levels may be a fixed resource at lower levels. Working within the administrative constraints, one can determine which resources are amenable to control and manipulation.

The second issue involves the time dimension of analysis. Only those resources which can be diverted to alternative uses over the analytical period are properly counted costs. For example, a manager of a training system may determine, through analysis, that considerable savings could be realized by choosing a system which would release currently used military facilities. The potential savings are unrealistic and should not be counted in evaluating the alternative when the saving is predicted on liquidation of these facilities and is not within the

manager's jurisdiction to liquidate, or when higher level decisions to liquidate would require a time lag extending beyond the operational period. The facilities actually have zero opportunity costs and are counted as a "free" resource for the evaluation of that particular alternative. The manager will make an operational decision to continue using the military facilities but he would at the same time make a planning decision to implement the necessary administrative procedures to liquidate the facilities to ultimately capture the long-term savings.

ADOPTION OF ADVANCED EDUCATIONAL TECHNOLOGY

Managers must constantly strive to identify and adopt those instructional techniques which provide the most efficient means of meeting the training objectives. The size of the training organization, the amount of training necessary, and the type of instruction and learning are variables which impact on the economic feasibility of introducing new technology. Each training system has unique characteristics and the adaptability of new technology must be decided on the merits of each individual system.

New technology may impact on both the efficiency and productivity of training. Technology which involves large capital outlays may only be economically efficient for the larger training systems where the investment can be distributed over the larger output. Each manager should question the economic feasibility of all available technology and adopt only those systems which are economically efficient. Too often managers believe that in order to maintain an effective and efficient training system they must adopt the most advanced technology available. While many systems could advantageously adopt the new training methods, other systems would make a serious economic error by adopting the same instructional strategy.

Technology may also impact on the productivity and quality of training. Different instructional methods which may involve equal expenditures of resources may not at all be equal in their ability to impart knowledge and training to the student. Assuming equal costs, the manager should select those systems which are the most effective in meeting training objectives.

REDUCTION IN COST OF RESOURCES

The value, or cost, of resources used in training is an exogenously determined variable over which managers of training systems have little, if any, control. The value of resources is largely determined by conditions in the general economy. Given an optimally designed and efficiently operated training system, the only way in which a system can continue to train to the same objectives in the face of rising resource costs is through a depletion of the capital base and/or an increase in

the budget. Fixed budget levels for periods over which resource costs are expected to increase will require a lowering of training objectives and/or a more rapid depletion of the capital base. Depletion of the capital base may be desirable, depending upon future expectations. Equipment which is expected to become obsolete should be rapidly depleted, since its opportunity cost will usually be near zero. Equipment in new condition and forced into obsolescence hardly represents a desirable use of resources.

Depletion of the capital base occurs through obsolescence and use. A more rapid and intensive use of these assets leads to their more rapid depletion. Therefore, a decision to go on a 24 hour training day to maintain the current training objectives and reduce the budget will result in a corresponding reduction of the physical life of the assets. If these assets must be replaced as they wear out, then a forced budget decision to utilize these assets more intensely shortens the life of the capital assets and hastens the day when they must be replaced. Again such adjustments may not necessarily be undesirable but they certainly should be recognized and made a part of the decision criteria.

Although managers cannot control the costs of resources, cost changes must be taken into account in their decisions. Disproportionate changes in resource prices will most often require readjustment in the configuration of training resources if an efficient training system is to be developed and maintained. When one set of resources becomes relatively more expensive than another through price decreases or increases, there will usually be some degree to which the less expensive resource can be substituted for the more expensive resource.

The most recent example of a major change in the relative prices of training resources evolves from the substantial increase in military personnel costs associated with the move to the all-volunteer armed forces. Personnel costs have increased to where these now account for the majority of the military budget. Higher personnel costs increase the probability that more capital intensive instructional systems are the more economically efficient systems.

In summary, there are few if any actions that managers of training systems can take to reduce the price or the cost of resources used in training. The cost of resources are exogenous to the system and represent variables to which managers must respond. Changes in resource prices do and must influence management actions. General and uniform price changes directly affect the operating budget requirements and disproportionate price changes affect both the budget and the configuration of resources which represent the most efficient training system possible.

REORGANIZATION TO CAPTURE SCALE ECONOMIES

Scale economies occur when a reduction in the average total training costs are associated with an increase in the outputs of the training system. Since the number of trainees required by operational units are determined outside the training command, managers do not have the option to arbitrarily set the output levels which drive average training costs to a minimum. Managers do have the option of capturing scale economies through consolidation of duplicate training facilities, or the combining and relocation of existing systems.

Scale economies arise from specialization and indivisibilities. Within the larger training systems, tasks can often be sufficiently segmented to warrant the use of specialized resources. The larger training systems are characterized by both qualitative and quantitative differences in the types of resources used. As training systems become larger, there is a greater opportunity to bring together a wider range of technological innovations and mesh them into a viable and efficient training system.

The first major factor contributing to scale economies arises from specialization in the use of capital and human resources. More scale economies can be attributed to the use of specialized capital than any other single cause. For large training systems, it is often more economical to choose equipment with high investment costs but with low variable costs of operation. Many Navy training courses with large throughputs are currently being revised for computerized instruction and many more are technically eligible candidates. Computerized instructional systems require relatively heavy capital investments and such investments cannot be economically justified for the smaller systems.

Specialization in the use of human resources is also an important factor contributing to scale economies. Managers in the larger systems have a greater opportunity to assign individuals to tasks for which they are highly qualified. Instructors can specialize in one course or in the use of training media, typists can be used only for typing, and the director can concentrate his total effort in managing the school. Personnel with unique training skills will have a greater opportunity to exploit these skills within systems which are of sufficient size to allow them to specialize and fully utilize their capabilities. In the smaller training systems, personnel will be required to perform a variety of tasks and will have little opportunity to specialize. It is recognized that in some instances a variety of tasks improves morale, but too much diversification leads to ineffective performance.

The second major contributing factor to scale economies stems from indivisibilities associated with capital and human resources. Indivisibilities arise from the inability to acquire and/or divide certain

resources into units which exactly match the training needs. Many resources, such as instructional material and personnel services, must be acquired in relatively discrete units or their services are not forthcoming or are ineffective. For example, instructional material cannot be developed in an amount that will be completely consumed as training takes place. Large investments must be made in this material before any of it is worth a great deal. When material is developed it can be used extensively with little additional cost. If the instructional material serves a system with a large throughput then the relatively heavy investment costs may be economically justified.

Indivisibilities in the use of human resources also play an important role in determining scale economies. Training programs require a minimum amount of personnel services regardless of scale. The smaller systems will, for example, require the services of a director but not his full-time service. The services of a director cannot be "divided up into small pieces" and used at several sites. Each small site must have the services of a director. Individuals assigned as directors to these small sites must function at less than capacity and/or perform supplementary duties. A director may be doing a creditable job while performing multiple functions but less fragmentation of the management effort would lead to more effective management.

There are numerous examples within the training community of the inability to acquire and use just that quantity of a resource necessary to perform the task. As a consequence, many of the resources used throughout the smaller training systems must be acquired in units with capacity that exceeds current needs. Furthermore, there are certain tasks which need be performed once and only once for each site, and the need to duplicate these tasks at each of several small locations leads to undesirable inefficiencies. The net result is that the total effort and resources expended in managing the several sites may exceed that which would be necessary with fewer sites. There is thus sufficient justification for an evaluation of training systems to determine if adjustments can be made to capture scale economies.

In summary, four areas are identified where managers may seek improvements in efficiency and productivity. First, cost reductions are often made possible by the use of new educational technology. Managers must evaluate and adopt for their training systems those technologies which reduce training costs and/or improve the quality of training. Second, there is no substitute for good quality management to insure that efficient and effective training systems are developed and maintained. Perhaps the greatest potential for cost reductions and improvements in productivity lies in the improvement of management at all levels within the command. Third, changes in the cost or price of resources will impact heavily on the total training budget. Managers will have little opportunity to control

the prices but they must respond to changes in the price of resources by reorganizing their training programs to more heavily utilize those resources which are relatively less expensive. Finally, there will often be opportunities to capture scale economies by combining courses, systems, or activities. Changes in educational technology and fluctuations in throughput levels are two of the major contributing factors which may dictate a change in the scale of the training system. Navy training is dynamic, both with respect to the type and quantity and must be constantly monitored for possible cost reductions through changes in the scale of operations.

CONCLUDING COMMENT

The requirement for economic analysis of training problems as required by DoD and Navy directives does not involve a set of highly esoteric analytical principles. With a minimum of training and experience, analysts can become quite proficient in performing analyses which adhere to the principles set forth in these directives. It is obvious that any organization which is highly efficient has been fulfilling the objectives of economic analysis. However, by formalizing the procedures of analysis and making explicit each facet of the analysis, managers will have a powerful tool to aid in decision making. Economic analysis was not intended to, nor could it, make the decision. There simply are too many qualitative factors involved in most decisions to enable the analysts to select a set of quantitative criteria which can be used alone as the basis for making totally objective decisions. Judgment and evaluation have always been required in management and decision making and will continue to play a significant role. When the amount of judgment required can be reduced by explicit economic analysis then decisions should be measurably improved.

REFERENCES

1. Analysis for Managers of People and Things. (undated) Department of Defense. Office of the Assistant Secretary of Defense (Comptroller).

2. Baker, B. N. Improving Cost Estimating and Analysis in DoD and NASA. Doctoral Dissertation. George Washington University. January 1972.

3. Braby, R., Henry, J. M., Parrish, Jr., W. F., and Swope, W. M. A Technique for Choosing Cost-Effective Instructional Delivery Systems, TAEG Report No. 16. April 1975. Training Analysis and Evaluation Group, Orlando, FL.

4. Department of Defense, Economic Analysis Handbook. 2nd Edition. Defense Economic Analysis Council, OASD(C)SP&I, Washington, D.C.

5. Department of Defense Instruction 7041.3, Economic Analysis and Program Evaluation for Resource Management. October 18, 1972.

6. Economic Analysis Handbook, Theory and Application, Vols. 1, 2, and 3, General Research Corp. McLean, VA. November 1973.

7. Economic Analysis Newsletter, Vol. 2, No. 2. Defense Economic Analysis Council. April 1975.

8. Fox, J. R. Proceedings, Ninth Annual Department of Defense Cost Analysis Symposium. September 1974.

9. Hitch, C. J., McKean, R. N. The Economics of Defense in the Nuclear Age. Harvard University Press, Cambridge. 1961.

10. Okun, A. M. The Political Economy of Prosperity. W. W. Norton Company, Inc. New York, N.Y. April 1969.

11. Personnel Systems Research Branch, Personnel Research Division, NAVPERS, Navy Military Manpower Billet Cost Data for Life Cycle Planning Purposes. April 1972.

12. Schmid, J. R., Hovey, R. K. Utility Theory and Optimization in Military Personnel Management, B. K. Dynamics, Inc. 1974.

13. Secretary of the Navy Instruction 7000.14A. Economic Analysis and Program Evaluation for Resource Management. March 14, 1973.

14. Winchester, E. W. Ordering Spending Priorities. Defense Industry Bulletin. May 1970.

GLOSSARY

Algorithm	A routinized computational procedure.
Capital	Assets of a permanent character having value and utility which extend over several discrete time periods. Examples are land, airplanes, buildings, instructional material, and simulators.
Diminishing Returns	The principle which illustrates the fact that as the quantity of any variable input increases relative to the fixed inputs the amount of total product declines because of the fixed resource base. For example, if all training resources were held constant except instructors then the numbers trained could be increased by adding additional instructors but each additional instructor would contribute less than the previous one added. Ultimately too many instructors would actually cause a drop in numbers trained.
Discount Rate	The interest rate used in calculating the present value of expected yearly costs and benefits. Represents the accepted price of money or the interest rate currently obtainable on loanable funds.
Discounting	A computational technique using the discount rate to calculate the present value of future benefits and costs. Used in evaluating alternative investment proposals that can be valued in money.
Economic Analysis	A systematic approach to the problem of choosing how to employ scarce resources and an investigation of the full implications of achieving a given objective in the most efficient and effective manner. The determination of efficiency and effectiveness is implicit in the assessment of the cost effectiveness of alternative approaches.
Economic Efficiency	That mix of alternative factors of production which results in maximum outputs, benefits, or utility for a given cost. Also that mix of productive factors which represents the minimum cost at which a specified level of output can be obtained.
Economies of Scale	Reductions in the average costs of output resulting from the production of additional units. Stems from (1) increased specialization of resources as output increases, and (2) greater opportunity to mesh existing resources into a viable unit.

GLOSSARY (continued)

Economy Solution	An economic efficient solution in which a specified output level has been attained with the minimum expenditure of resources.
Efficiency Solution	An economic efficient solution in which the amount of output has been maximized for a given amount of resources.
Engineering Estimate	An estimate of costs or results based on detailed measurements or experiments and specialized knowledge and judgment.
Explicit Costs	Those costs involved in the acquisition of resources for which the agency or activity must make explicit monetary payments or budget allocations.
Externalities	Benefits and costs (economy or diseconomy) that affect parties other than the ones directly involved. Sometimes referred to as spillover effects. An external economy is a benefit received by one from an economic activity of another for which the beneficiary cannot be changed. An external diseconomy is a cost borne or damage suffered consequent to the economic activities of others for which the injured is not compensated.
Implicit Costs	The costs attributed to the use of resources for which there are no explicit budget allocations or monetary payments required. Implicit costs are the opportunity costs of using resources already owned or in inventory.
Incommensurables	Consequences of alternatives being compared that cannot be translated into numeric terms. For example, the psychological impact on the community of a decision, such as losing a fire station, could not be put into numeric values in the same manner as increases in losses due to fires.
Incremental Cost	See marginal cost.
Instructional Delivery System	The instructional system which consists of the student and all of the elements with which he interacts to achieve instructional goals. Included are the instructional media, both hardware and courseware, the instructor, other students in peer instruction, and the direct supporting services for equipment maintenance and development.

GLOSSARY (continued)

Marginal Analysis	Technique for evaluating an added increment. A basis for comparing the added cost to the benefit gained. The term, marginal, refers to the last increment of whatever is being considered. Benefits per unit of cost will be maximized when the additional increment of benefits and additional increment of costs are equal. At any other point, either additional benefits could be obtained at less additional cost, or additional benefits obtained would be less than the additional costs incurred.
Marginal Cost	Change in total cost due to a unit change in output. It is often used synonymously with incremental costs but the latter is usually considered a more general term. Thus we speak of the marginal cost of training one additional student as the incremental cost of introducing a new training system.
Marginal Utility	The change in total utility due to a change of one unit in the quantity of a good or service consumed.
Opportunity Cost	The benefits that could have been obtained by the best alternative use of resources which have been committed to a specific use. The measurable sacrifice foregone by forsaking an alternative investment.
Present Value	The present worth of past or future benefits and costs determined by applying discount procedures to make alternative programs and actions comparable regardless of time differences in money flows.
Present Value Benefit	Calculation of each year's expected benefits multiplied by its discount factor and then summed over all years of the planning period.
Present Value Cost	Calculation of each year's expected cost multiplied by its discount factor and then summed over all years of the planning period.
Program Evaluation	Program evaluation is the appraising of the efficiency and effectiveness of ongoing or completed programs. Aims at a program improvement through comparisons of existing programs with alternative programs and techniques. Uses actual performance data to gauge progress towards program goals.

GLOSSARY (continued)

Resources	Assets available and anticipated for generations. Includes people, equipment, facilities and other things used to plan, implement, and operate an economic activity.
Social Cost	The total cost of an activity which includes both public and private costs.
Sunk Costs	The funds expended as a result of a prior decision. Previous expenditures of funds, or sunk costs, have no bearing on current decisions. One must not confuse the expenditures making up sunk costs with the resources acquired from those expenditures. All resources are relevant in economic decisions and must be included at some positive value if they have a valuable alternative use.
Uniform Annual Costs	The total present value cost divided by the sum of the present value factors of the years in which the alternative yields benefits. This gives an average cost per year of production.

APPENDIX A

COST MODEL: DISCUSSION, ASSUMPTIONS AND LIMITATIONS[4]

An economic analysis is a critical step in the design of training systems. A rational choice of an instructional delivery system cannot be based upon training effectiveness without regard to cost and vice versa. In order to facilitate the economic analysis of instructional systems, a cost model has been constructed. The model is simply a computational algorithm for determining both the cost of the components of the total instructional delivery system.

An economic analysis requires that alternatives be identified and associated resources specified. These determinations must be made prior to the use of the cost model and constitute the input data for the model. The Training Effectiveness, Cost Effectiveness Prediction Technique (TECEP) approach provides a systematic procedure for the identification of feasible training systems and associated resource requirements. After alternatives have been identified and their resource requirements specified they must be "costed" and time phased. The most common method of costing is to place dollar values on the resources. These values can be time phased, discounted, and summed to represent the present cost of each alternative.

The assumptions and objectives underlying the comparative costing of proposed media sets determine which resources are relevant and how these resources are valued. The interpretation of the output of the cost model is dependent upon these assumptions and objectives. For certain objectives the outputs have only relative meaning while for other applications the outputs could have absolute meaning.

When the objective of the analysis is to select the most efficient alternative from among a specified set, all of which are capable of meeting the training objectives, then the resources common to all alternatives can be factored out and ignored in the analysis. When the objective is to determine the total absolute long-run costs of training, then all resources used for training must be included and evaluated at their opportunity cost. When the objective is to determine the budget requirements to implement and operate a system, then the cost of resources which must be acquired plus the current costs of operation are the relevant costs.

In the use of the following cost model, the objectives of the analysis must be clearly specified and resources identified and priced accordingly.

[4] Adopted from Braby, R., Henry, J. M., Parrish, Jr., W. F., and Swope, W. M. A Technique for Choosing Cost-Effective Instructional Delivery Systems. TAEG Report No. 16. April 1975. Training Analysis and Evaluation Group, Orlando, FL.

A meaningful economic analysis requires that alternatives be available, one of which may be the status quo. By making explicit all of the alternatives and their resource requirements, the analysis can often be greatly simplified. Resources which are common to all alternatives and difficult to evaluate can be factored out of the analysis.

Resources which are factored out are, nevertheless, a part of the total long-run cost of training. If the decision to undertake training is contingent upon the benefits to be acquired versus total training costs, then these resources must be evaluated and the total cost weighed against the benefits accruing from the training.

Most military tasks have become so sophisticated that the need for training is axiomatic. Often the pertinent question is how best to do the training and not whether or not to do the training. When the decision is already made to undertake the training to achieve a particular proficiency level, then the benefits of any particular alternative over another can be measured with respect to the next most efficient alternative. Relative or incremental costing of alternatives provides sufficient information for selection of the more efficient alternatives.

It is anticipated that many users of the TECEP approach and the cost model will be administrators at the operational level. These individuals most often encounter problems of how best to provide a given level and quantity of training. They seldom have an opportunity to control these variables. Administrators at this level are most often faced with cost minimization problems and are primarily interested in planning their training system to most efficiently accomplish their training goals. They often have little need to determine the value or worth of training and, hence, have little need to compute a benefit-cost ratio.

While the emphasis of the TECEP approach is on cost minimization (fixed output levels), there will be requirements for analysis in which benefits fluctuate in response to training approaches. The evaluation of differential benefits accruing from different training approaches is a complex problem and one which has been beyond the objectives of this model. While the cost model can be used to evaluate the resources required for various training approaches, it does not, nor was it intended to, provide a method of assessing differential benefits or effects of alternative training approaches.

The basic output of the cost model is the present value (cost) of each alternative. Additional arithmetical computations are presented. The latter include the total and average annual cost per student position, the average cost per graduate and a distribution of the incidence of costs over the life of the alternative being evaluated.

For most applications of the model, the analysts will be required to access multiple data sources. Past records of operational units provide one valuable data source. Personnel data published by NAVPERS, and other similar types of data, can be used for estimates of personnel costs. While the model requires rather detailed breakdown of certain data, the model can be used to advantage even when many of these data are not highly reliable. However, data reliability must be recognized in the interpretation of results.

There are numerous limitations in the use of the model. First, and perhaps most significant, the model is not capable of identifying or selecting (from among the feasible set) the most efficient media. The model does not utilize any optimization criteria for ascertaining effectiveness or efficiency. Its use is limited to a cost determination of proposed alternatives (media sets) and only through an iterative use of the model could one hope to move toward more efficient solutions. Furthermore, the model is not designed to predict or forecast the total cost of a system for which a planner must budget resources. Its primary purpose is to aid in selecting the most efficient instructional medium.

Second, the model is constructed upon the assumption that for any specified planning period there will be some resources which must be used as they exist and others which can be varied to accommodate various training numbers and levels. However, there is both an absolute limit and an efficient limit to the amount of variable resources which can be expanded against a fixed set of resources and one must be cognizant of these limitations in the use of the model.

A basic computational unit for which many of the variable costs are entered in the model is the "student position."[5] The number of student positions required, and hence the variable resources, is computed as a function of the training requirements. The training requirements are exogenously determined and reflect both numbers trained and course characteristics.

Changes in educational technology which have the effect of reducing the time required in the media may result in the need for fewer student positions and lower numbers of students in training to fulfill training requirements. These cost savings would be reflected in the model. The impact of introducing educational technology which has no effect on the resource requirements or time spent in training cannot be evaluated with this cost model. The model is not designed to evaluate the effects of introducing technology in which the impact occurs entirely on the benefit side.

[5] A student position may be a carrel and related instructional material, a classroom position and related equipment, a flight simulator, or it might be uniquely defined in terms of the system being analyzed.

Third, the model assumes all variable cost functions are linear--an assumption that may not be tenable for specific training situations.

Fourth, the model does not provide any means for evaluation of secondary, or spillover, effects of alternative training approaches.[6] These effects are implicitly assumed to be constant (or equal) for alternatives considered. If such effects do in fact exist, they must be evaluated outside the model. A general model cannot be defined in sufficient detail to cover all possible contingencies. These contingencies may require the user to exercise judgment in his interpretation of input variables. The important consideration is that all relevant costs be included and that data are entered in the input variables in a manner which avoids double counting.

The user may often find it convenient to redefine certain variables in order to reduce the complexity of the input data for specific applications. Such changes can be made by identifying the relevant functional relationships in the FORTRAN program and making changes in these relationships where necessary.

If the analyst is willing to make certain assumptions about the structure of the cost data at various points throughout the model, then a number of the input variables are not relevant and can be entered as zero. For example, if the instructional material is developed prior to implementation and no further development is undertaken during the planning period then the variable concerning the dollars required for instructional material development is zero for all years in the planning period. Similarly, if it can be assumed that the instructional material has no remaining value at the end of the planning period, then the variable concerning the remaining value of instructional materials is equal to zero. A willingness to eliminate many of these factors by assumption would enable the analysts to reduce the complexity of the input data.

An effort was made in constructing the model to gain as much flexibility as possible, yet not at the expense of eliminating the model usefulness for analysis of less complex problems.

The input variables are classified into seven classes as follows: (1) facilities, (2) equipment, (3) instructional material development,

[6] Secondary effects are those effects which occur outside the influence of the decision-making unit. Therefore, the decision maker does not normally consider the impact of secondary effects when making his decision. However, from a societal viewpoint these effects may be extremely important. An example of a secondary effect, and one not normally considered in evaluating military training, is the worth of the training to the individual in preparing him for a civilian occupation.

(4) personnel, (5) students, (6) supplies, and (7) miscellaneous. A definition of each variable follows:

1. Facilities

FACOST	Total costs of facilities acquisition and refurbishing which are necessary for implementation.
LOFFA	Expected years of life of FACOST assets.
CPSQFT(I)	The annual cost of operation and maintenance of facilities per square foot (includes operation, maintenance, janitorial service, utilities, etc.). Include the annual opportunity costs of facilities where applicable.
SQFTIN	Total square feet required for each instructor.
SQFTST	Total square feet required per student position.
SQFTAM	Total square feet required for administrative overhead.

2. Equipment

EQCISP	The cost of equipment necessary for implementation (that which is not dependent on the number of student positions). Do not include equipment which is uniquely associated with student positions (i.e., costs included in variable EQIMPC).
LOFEQ1	The expected years of life of equipment included in EQCISP.
CAQSP(I)	Total cost of equipment to be acquired in each year of planning period following implementation. Include cost of equipment which represents expansion or addition to the program plus replacement costs for that equipment included in EQCISP.
LOFEQ(I)	The expected years of life of equipment which has been included in CAQSP(I).

OMFEQ(I) — Total annual operation and maintenance cost of fixed equipment; i.e., the operation and maintenance cost of equipment not uniquely related to student positions. O&M costs of equipment included in variable EQCISP and CAQSP(I).

EQIMPC — The cost of equipment (per student position) which must be acquired for implementation. Do not include equipment which is not uniquely related to student positions (i.e., do not include equipment costs included in variable EQCISP).

LOFEQ — The expected years of life of student position equipment; i.e., equipment included in EQIMPC.

COPMT(I) — Annual operation, maintenance, and replacement costs of equipment associated with each student position in each year of the planning period; i.e., the O&M costs of equipment included in variable EQIMPC and the replacement costs of any student position related equipment.

TSPOSD — The percentage of planned operating time the student position equipment is nonfunctional because of unplanned contingencies; i.e., equipment failure, weather, etc. (percentage of down time equals one minus the percentage availability).

3. Instructional Material Development

UIMD — The percentage of time spent in the training medium (for the nonrecycled student) for which unique hours of instructional material must be developed.

UIMDYR(I) — The number of unique hours of new instructional material to be developed in each year of the planning period. (The model assumes that any material developed and reflected in this variable is unique to the course and will be fully depreciated at the end of the planning period.) This variable does not include any updating of original course material.

UPDATE	Update factor for instructional material. Percentage of the original development of instructional material expended each year to maintain the courseware.
EVIM	The percentage of the original development cost of the instructional material which remains at the end of the planning period.
CIMD	Average cost of developing the master copy for one hour of instruction (i.e., the per unit instructional material development costs).

4. Personnel

INTSPO	Instructor-to-student position ratio.
SALINR	Average annual salary and benefits for one instructor.

5. Supplies

SUPPLY	Average cost of expendable supplies per student while in the training medium.

6. Students

GRAD(I)	The number of students who must be trained for each year of the planning period; i.e., the number who must complete the program and graduate.
STUDSL	Average annual salary and benefits for one student.
STCST1	Average student travel costs to and from school. Do not include any travel done as part of the course.
STCST2	Average student travel costs which are incurred as part of the course. Do not include any costs to and from school.

7. Miscellaneous

N	The number of years in the planning period. (In setting the planning period, guidance can be found in SECNAVINST 7000.14A, pages 7 and 8.)

WSHOP1	Number of training weeks available per year (60 hours per week for 50 weeks is equal to 75 training weeks per year).
ARATE	The attrition rate. The percentage of students who enroll in the program but never complete the training.
DRATE	The discount rate (10 percent according to DoD Instruction 7041.3).
WSCHOP	The time in weeks the student position is available per year.
TLENGH	The average time in weeks spent in the training medium for the nonrecycled student.
TLEGTH	The average hours per week the student spends in the medium.
RCRATE	Recycle rate equals the percentage of students enrolling in the training who will repeat some part of the program.
ARCYTM	Average recycle time in weeks equals the average amount of time a student spends in repeating any and all parts of the course.
ESP	The percentage of student positions above the computed number which are to be acquired to provide for fluctuations in student inputs through the system.

The following variables are computed by the model from the above input data:

1. Facilities

TSQFT	Total square feet of facilities required:
	TSQFT=(SQFTST)(PSP)+(INTSPO)(PSP)(SQFTIN)+SQFTAM.
FCOST(I)	Total cost of facilities for each year of the planning period:
	FCOST(I)=(TSQFT)(CPSQFT(I)).

2. Equipment

NSPR(I) — Number of student positions required for the system:

$$NSPR(I)=((SMWRRC(I)+STUDMW(I))/(WSHOP1)/(1-TSOPSD).$$

MNSP — Mean number of student positions for planning period:

$$MNSP=\sum_{I=1}^{N} NSPR(I)/N.$$

PSP — Planned number of student positions:

$$PSP=MNSP+(ESP)(MNSP).$$

EAQCI — Equipment acquisition costs necessary for implementation:

$$EAQCI=(EQIMPC)(PSP)+(EQCISP).$$

TAEQC(I) — Total annual operation, maintenance and equipment acquisition costs for each year of the planning period:

$$TAEQC(I)=(CAQSP(I)+(COPMT(I))(PSP)+OMFEQ(I).$$

E_3 — Annual depreciation of student position equipment:

$$E_3 = (EQIMPC)(PSP)/LOFEQ.$$

R — Internal computed variable indicating the years of life remaining in equipment at end of planning period.

RVEQ — Remaining value of student position equipment at end of planning period:

$$RVEQ=(R)(E_3).$$

RVEQ2 — Remaining value of equipment purchased in each year of planning period (- for all $(LOFEQ(I) -N)\geq 0$):

$$RVEQ2=\sum_{I=1}^{N}(LOFEQ(I)-N) * (CAQSP(I)/LOFEQ(I)).$$

RVEQ3 — Remaining value of equipment purchased for implementation (-for all (LOFEQ1-N)≥0):

RVEQ3 = (LOFEQ1-N) * EQCISP/LOFEQ1.

3. Instructional Material

ACIMD — Instructional material development costs for implementation:

ACIMD=(CIMD)(UIMD)(TLEGTH)(TLENGH).

CUIMD(I) — Total cost of developing instructional material in each year of planning period:

CUIMD(I)=(CIMD)(UIMDYR(I)).

AIMMC(I) — Maintenance costs of instructional material for each year of planning period:

AIMMC(I)=CUIMD(I)+(ACIMD)(UPDATE).

RVIM — Remaining value of instructional material at end of planning period:

RVIM=(ACIMD)(EVIM).

4. Personnel

RINSTR(I) — Number of instructors required:

RINSTR(I)=(INTSPO)((SMWRRC(I)+STUDMW(I)))/WSCHOP(1-TSPOSD)

CINSTR(I) — Total costs of salary and benefits for all instructors for each year of planning period:

CINSTR(I)=(SALINR)(RINSTR(I)).

5. Students

STUD(I) — Student inputs necessary in each year to provide the required number of graduates:

STUD(I)=GRAD(I)/(1-ARATE).

AINSTR — Average number of instructors required for all years in the planning period:

$$AINSTR=\sum_{I=1}^{N} RINSTR(I)/N$$

AASIN — Average annual student inputs required to provide the number of graduates specified in each year:

$$AASIN=\sum_{I=1}^{N} STUD(I)/N.$$

STUDMW(I) — Total time required in training for all students in each year of planning period to train the required number of students (to specified objectives) utilizing the media set under consideration (exclude recycle time):

$$STUDMW(I)=(TLENGH)(STUD(I))(1-0.5(ARATE)).$$

SMWRRC(I) — Total time required for recycling for all students in each year of planning period:

$$SMWRRC(I)=(RCRATE)(STUD(I))(ARCYTM).$$

AOB(I) — Average number of students on board for each year:

$$AOB(I)=(SMWRRC(I)+STUDMW(I))/WSCHOP.$$

AAOB — Mean number of students on board for entire planning period:

$$AAOB=\sum_{I-1}^{N} AOB(I)/N.$$

TRAVEL — Total annual travel costs for all students:

$$TRAVEL=(AASIN)(STCST1)+(STCST2)(AASIN)(1-0.5\ ARATE).$$

SSALRY(I) — Total costs of student salary and benefits for all students for each year of planning period:

SSALRY(I)=((SMWRRC(I)+STUDMW(I))/52)(STUDSL).

6. Supplies

SUPPY(I) — Total cost of student supplies for each year in planning period:

SUPPY(I)=(STUD(I))(SUPPLY).

7. Miscellaneous

UDACST(I) — Total nondiscounted costs for each year in planning period:

UDACST(I)=FCOST(I)+TAEQC(I)+AIMMC(I)
+CINSTR(I)+SUPPY(I)+SSALRY(I)+TRAVEL.

H_4 — Total nondiscounted cost of alternative:

$$H_4=\sum_{I=1}^{N} \text{UDACST}(I)+\text{FACOST}+\text{EAQCI}+\text{ACIMD} - \text{RVAS}/(1+\text{DRATE})^N.$$

RVAS — Remaining value of equipment and instructional material at end of planning period:

RVAS=RVEQ+RVIM+RVFA

PVALUE — Present value (cost) of alternative:

$$\text{PVALUE}=\sum_{I=1}^{N}((\text{UDACST}(I)(2+\text{DRATE}))/(2(1+\text{DRATE})^I))+[\text{FACOST}+\text{EAQCI}+\text{ACIMD}]-[\text{RVAS}/(1.0+\text{DRATE})^N].$$

C_3 — Average discounted costs per student position:

C_3=PVALUE/PSP

CINT — Initial system acquisition costs for facilities, equipment, and instructional material development:

CINT=FACOST+EQACI+ACIMD.

ANCSP — Average annual nondiscounted costs per student position.

$$ANCSP=H_4/(N)(PSP)$$

ADCSP — Average annual discounted costs per student position:

$$ADCSP=PVALUE/(N)(PSP)$$

ACSP — Initial system acquisition costs for facilities, equipment, and instructional material development per student position:

$$ACSP=CINT/PSP.$$

UAC — Uniform annual costs:

$$UAC=PVALUE/\sum_{I=1}^{N}\left[(2+DRATE)/(2(1+DRATE)^{I})\right].$$

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